PATENT ABSTRACTS OF JAPAN

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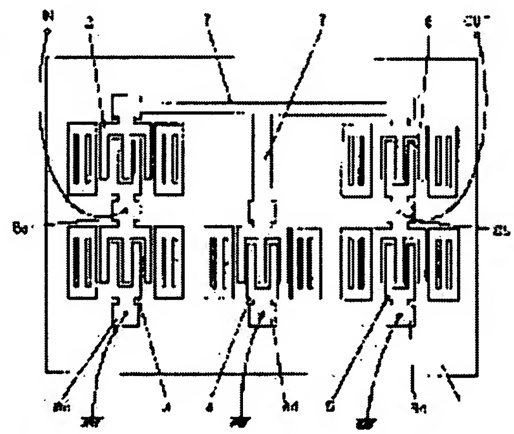
(21)Application number : 10-314241
(22)Date of filing : 05.11.1998
(71)Applicant : TOYO COMMUN EQUIP CO LTD
(72)Inventor : OWAKI TAKUYA

(54) LADDER-TYPE SAW FILTER

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a means for making steep the attenuation gradient of the ladder type SAW(surface acoustic wave) filter constituted by arranging plural SAW resonators on a piezoelectric substrate.

SOLUTION: This SAW filter is constituted by arranging on the piezoelectric substrates plural SAW resonators 2 to 6 formed, by arranging IDT electrodes in the propagation direction of a surface wave and grating reflectors on both their sides. Here, on electrode finger width L of the grating reflectors and a space S are so related that $0.55 \leq L/(L+S) \leq 0.75$.



LEGAL STATUS

[Date of request for examination] 31.03.2000
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CLAIMS

[Claim(s)]

[Claim 1] The ladder mold SAW filter characterized by setting the electrode digit L of said IDT electrode and said grating reflector, and relation with a tooth space S to 0.55 <=L/(L+S) <=0.75 in the ladder mold SAW filter which arranges two or more SAW resonators which come to allot a grating reflector to an IDT electrode and its both sides along the propagation direction of a surface wave, and constitutes them on a lithium tantalate substrate.

[Claim 2] The ladder mold SAW filter according to claim 1 characterized by using the lithium tantalate substrate whose cutting include angle theta is 38 degrees <= theta<=44 degrees.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the ladder mold SAW filter which has improved the attenuation slope near the pass band about a ladder mold SAW filter.

[0002]

[Description of the Prior Art] In recent years, especially many SAW devices in a cellular-phone vessel etc. are used from having the description which was used widely and was [nature / high performance, small, / mass-production] excellent in the communication link field. It is the so-called ladder mold SAW filter which used for RF stages, such as a cellular-phone machine, and has arranged 1 terminal-pair surface acoustic wave resonator (SAW resonator is called hereafter) plurality to the average and a serial on the same piezo-electricity substrate at one sort of a **** SAW filter. Since it constituted only from a high SAW resonator of Q value compared with other electronic parts and the filter of steep attenuation slope was realizable while being a low insertion loss, the description of a ladder mold SAW filter came to be widely used as RF filters, such as a cellular phone, in recent years.
[0003] Drawing 5 is the top view of the electrode pattern in which the configuration of one SAW resonator which forms a ladder mold SAW filter is shown, on the piezo-electric substrate 11, arranges the grating reflectors 13a and 13b on the IDT electrode 12 and its both sides along the propagation direction of a surface wave, and constitutes a SAW resonator. The IDT electrode 12 is constituted by the radial fin type electrode of the pair which has two or more electrode fingers put mutually in between, respectively, it is the IDT electrode 12, while goes away, uses a form electrode as an input terminal, and uses the radial fin type electrode of another side as an output terminal.
[0004] The ladder mold SAW filter shown in drawing 5 (b) places and arranges the distance which does not do effect along the propagation direction of a surface wave mutually the SAW resonator shown in drawing 5 (a), and five same SAW resonators (14-18) on the piezo-electric substrate 11, and it connects it using a signal line 19, the ground electrode 20, and an earth wire 21 so that it may become ladder structure to juxtaposition, a serial, juxtaposition, and .. one by one about them.
[0005] If the electrical equivalent circuit of a ladder mold SAW filter shown in drawing 5 (b) is typically expressed using the sign showing a piezo resonator (a

SAW resonator is also one sort of a piezo resonator), it will become the ladder mold circuit shown in drawing 6 R> 6. That is, the SAW resonators 15, 16, and 17 are connected to the serial arm for the SAW resonators 14 and 18 to the input/output terminal at the juxtaposition arm among each component shown in drawing 5 (b). If the frequency and many electric constants of each SAW resonator which are shown in drawing 6 are set up according to the filter theory and termination is carried out suitably, functioning as a band pass filter of an owner pole configuration is known well.

[0006] It is indicated that the insertion loss at the time of forming a ladder mold SAW filter on a lithium tantalate (LiTaO3) substrate, attenuation slope, etc. are greatly dependent on cutting bearing and electrode layer thickness of a substrate as amelioration of a SAW device is progressing quickly every year, for example, is indicated by JP,9-167936,A. That is, if a ladder mold SAW filter is formed so that electrode layer thickness H/lambda (wavelength of the surface wave by which lambda is excited) may fulfill 0.07 <= H/lambda <=0.1 and the conditions whose cutting bearings Y of a substrate are 38 degrees <= Y<=44 degrees, while an insertion loss will turn into low loss, it is described that a ladder mold SAW filter with the steep attenuation slope near the pass band is obtained.

[0007] drawing 7 -- a piezo-electric substrate -- 42-degreeY-X LiTaO3 -- using -- an electrode -- thickness H/lambda of an aluminium alloy -- 0.08 and an IDT electrode -- 100 pairs of logarithms The filtering property of the filter which connected to parallel series five SAW resonators which used crossover width of face W of 100 and an electrode finger to 30lambda, and used resonance frequency as the 880MHz band for the number of a reflector, respectively as shown in drawing 6 in drawing for which it asked by simulation Overwrite of the thing A which expanded and illustrated only the thing B and pass band which were illustrated including the inhibition zone about the filter shape is carried out. The loss (Loss) of the expanded filter shape supports to a right-hand side axis of ordinate, and the frequency (Freq.) supports the numeric value of the lower berth. In addition, As shown by hatching shows the specification of a pass band, and Bs

shows the specification of a decay area. In addition, the electrode digit (Rhine width of face) L and the dimension (tooth-space width of face is called hereafter) of the tooth space S between electrode fingers are set up equally.

[0008]

[Problem(s) to be Solved by the Invention] however -- a U.S. AMPS method -- the frequency of a 900MHz band -- using -- frequency spacing of transmission and reception -- 20MHz -- it is -- a fractional bandwidth -- 4.5% of RF filter -- being required -- it receives, and it will be necessary for frequency spacing of transmission and reception to continue being 20MHz although the frequency band shifted to the 1.9GHz band, and to make steeper attenuation slope 4.0% of fractional bandwidths, a narrow-band, and near the pass band compared with the conventional thing as an RF filter by the new PCS method There was a problem that it was very difficult to fill new specification with the above-mentioned ladder mold SAW filter. It is made in order that this invention may solve the above-mentioned problem, and it aims at offering the ladder mold SAW filter which has improved attenuation slope.

[0009]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, it found out that the purpose could be attained if it is made to be the following as a result of examining the relation between the electrode digit L of IDT, and the tooth-space width of face S in this invention. That is, invention according to claim 1 is a ladder mold SAW filter characterized by setting the electrode digit L of an IDT electrode and a grating reflector, and relation with a tooth space S to 0.55 <=L/(L+S) <=0.75 in the ladder mold SAW filter which arranges two or more SAW resonators which come to allot a grating reflector to an IDT electrode and its both sides along the propagation direction of a surface wave, and constitutes them on a piezo-electric substrate. Invention according to claim 2 is a ladder mold SAW filter according to claim 1 characterized by using the lithium tantalate substrate whose cutting include angle theta is 38 degrees <= theta<=44 degrees.

[0010]

[Embodiment of the Invention] This invention is explained to a detail based on the gestalt of operation shown in the drawing below. Drawing 1 is the top view showing the configuration of the ladder mold SAW filter concerning this invention, and five SAW resonators (SAW resonators 2-6) which were explained by drawing 5 on the piezo-electric substrate 1 are allotted, it connects with the average and a serial using the lead electrode 7 and two or more electrode pad 8 a-e, and it constitutes a ladder mold SAW filter. Each SAW resonator 2-6 ** distance which does not do effect mutually, and is arranged. Moreover, electrode pad 8a, an input terminal IN, and electrode pad 8b and an output terminal OUT are electrically connected using wirebonding, and the electrode pads 8c-8e are grounded, respectively, and constitute a ladder mold SAW filter.
[0011] In order to improve the insertion loss of a ladder mold SAW filter, and the attenuation slope near the pass band, it is necessary to improve the property R of the SAW resonator which constitutes the filter, for example, electrical equivalent resistance, a capacity factor gamma, etc. Then, like drawing 2 which shows some sectional views of a SAW resonator, when an electrode digit (Rhine width of face) L and the tooth-space width of face S were defined, the artificer repeated the experiment variously so that he may ask for the electrical equivalent resistance R of the ratio of an electrode digit L to both sum, i.e., Rhine pulse duty factor L/(L+S) and a SAW resonator, and the relation of a capacity factor gamma. In addition, in this drawing, lambda is equivalent to one wave, and H is the thickness of an electrode layer and, generally expresses the thickness of a SAW resonator by H/lambda. a piezo-electric substrate -- 42-degreeY-X LiTaO3 -- using -- an electrode -- thickness H/lambda of an aluminium alloy -- 0.08 and an IDT electrode -- the logarithm was set to 30lambda and the frequency used [the logarithm] the number of 100 pairs and a reflector as the 900MHz band for the crossover width of face W of 100 and an electrode finger, respectively. Rhine pulse duty factor L/(L+S) was changed in the unit of 0.1 from 0.3 to 0.7, the circle diagram and the resonance characteristic at that time were measured, and it measured resonance frequency fs, antiresonant frequency fa, a capacity factor

gamma, equivalent resistance R, and spurious one.

[0012] The circle diagram and the resonance characteristic which were shown in drawing 2 (b) and (c) are a measured example, and, as for resonance frequency and Point beta, Point alpha shows antiresonant frequency. Drawing 3 (a) and (b) are drawings which divided into a capacity factor gamma and the electrical equivalent resistance R the data obtained from the above measurement, respectively, and plotted them to Rhine pulse duty factor L/(L+S). Drawing 3 (a) shows that a capacity factor gamma serves as the minimum value when Rhine pulse duty factor L/(L+S) is about 0.47. Moreover, along with the increment in the Rhine pulse duty factor, the electrical equivalent resistance R tends to decrease in general from drawing 3 (b).

[0013] The artificer's capacity factor gamma was small, and although the insertion loss was small when a ladder mold SAW filter was constituted using a small SAW resonator, and the attenuation slope near the pass band thought that it became steep and being experimented, when the capacity factor gamma constituted the ladder mold SAW filter from the minimum value using the SAW resonator of a big value for a while, pass band bandwidth had the capacity factor gamma equivalent to the min thing, and equivalent resistance R found out that the attenuation slope near the pass band became steep rather.

[0014] Then, 42-degreeY-X LiTaO3 is used for a piezo-electric substrate that the above-mentioned thing should be checked. an electrode -- thickness H/lambda of an aluminium alloy -- 0.08 and an IDT electrode -- 100 pairs of logarithms The filtering property of the filter which connected the number of a reflector to that of drawing 6 for five SAW resonators which used crossover width of face W of 100 and an electrode finger to 30lambda, and used resonance frequency as the 880MHz band, respectively like at parallel series It asked by simulation using experimental values, such as the capacity factor gamma of the aforementioned SAW resonator, and the electrical equivalent resistance R. Drawing 4 is drawing having shown the filtering property when the capacity factor gamma of a SAW resonator sets it as the Rhine pulse duty factor 0.7 which presents a big value for

a while from the minimum value, and overwrite of the thing A which expanded and illustrated only the thing B and pass band which were illustrated including the inhibition zone about the filter shape is carried out. The frequency (Freq.) supports [the loss (Loss) of the expanded filter shape] the right-hand side axis of ordinate to the numeric value at the lower berth. In addition, As which performed hatching shows the specification of a pass band, and Bs shows the specification of a decay area. It turns out that the ladder [pulse duty factor / Rhine] mold SAW filter using 0.7 of the attenuation slope near the pass band is steeper so that clearly from drawing 4 and drawing 7 .

[0015] Furthermore, although, as for the pass band width of the place decreased 1.5dB from the minimum loss, both showed the almost same value when drawing 4 and 7 were examined in the detail, it turned out that the direction of the ladder mold SAW filter which used the Rhine pulse duty factor 0.7 has become narrower about about 7% than the filter of the Rhine pulse duty factor 0.5 as for the bandwidth of the place decreased 30dB. That is, from the filter with which the direction of the ladder mold SAW filter which set the Rhine pulse duty factor as 0.7 set the Rhine pulse duty factor as 0.5, I hear that the attenuation slope near the pass band becomes steep, and there is. Furthermore, when the experimental value was used for a capacity factor gamma, the electrical equivalent resistance R, etc., the Rhine pulse duty factor was made into the parameter, the filtering property of a ladder mold SAW filter was searched for by simulation, and Rhine pulse duty factor L/(L+S) filled the relation of 0.55 <= L/(L+S) <=0.75, it turned out that attenuation slope is improved from the conventional filter made into the Rhine pulse duty factor 0.5.

[0016] Although it asked for the relation by which the attenuation slope near the pass band is improved in the above explanation about the case where the IDT electrode of the SAW resonator arranged on the piezo-electric substrate and the Rhine pulse duty factor of a grating reflector are changed by the same ratio, since resonance frequency will also change if the Rhine pulse duty factor is changed, it cannot be overemphasized that the wavelength of a grating reflector

is adjusted so that it may become the optimal to the bandwidth of a filter about the center of the stop band which a grating reflector forms.

[0017] Moreover, although the above explanation explained the cutting include angle theta of a lithium tantalate substrate about the case where 42 degrees is used, even if it used the cutting include angle of the range whose cutting include angle is 38 degrees <= theta<=44 degrees, the same result as the above was obtained. Moreover, it is 0.07<=, without restricting to this value, although the case of 0.08 was explained about electrode layer thickness H/lambda. The result with the same said of what was set as the range of H/lambda <=0.1 was obtained.

[0018]

[Effect of the Invention] Since this invention was constituted as explained above, it became possible [making attenuation slope near the pass band steep]. Therefore, it is **** about the outstanding effectiveness that the cellular phone which was excellent in communication link quality when using the filter which becomes this invention for RF filters, such as a cellular phone of a 1.9GHz band, is realizable.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing the configuration of the ladder mold SAW filter concerning this invention.

[Drawing 2] (a) They are drawing explaining the Rhine pulse duty factor, the (b) circle diagram, and drawing showing (c) resonance characteristic.

[Drawing 3] (a) They are drawing showing the relation between Rhine pulse duty factor L/(L+S) and a capacity factor gamma, and drawing showing the relation between (b) Rhine pulse duty factor L/(L+S) and the electrical equivalent resistance R.

[Drawing 4] It is drawing showing the filtering property of the ladder mold SAW filter concerning this invention.

[Drawing 5] (a) They are drawing showing the configuration of a SAW resonator, and drawing showing the configuration of (b) ladder mold SAW filter.

[Drawing 6] It is the electrical equivalent circuit of a ladder mold SAW filter.

[Drawing 7] It is drawing showing the filtering property of the conventional ladder mold SAW filter.

[Description of Notations]

1 .. Piezo-electric substrate

2, 3, 4, 5, 6 .. SAW resonator

7 .. Lead electrode

8a, 8b, 8c, 8d, 8e .. Electrode pad

L .. Electrode digit (Rhine width of face)

S .. Tooth space

lambda .. Wavelength

H .. Electrode layer thickness

alpha .. Resonance point

beta .. Antiresonance point

A .. Pass band property

B .. Decay area property

As .. Specification of a passband

Bs .. Specification of a decay area

[Translation done.]

* NOTICES *

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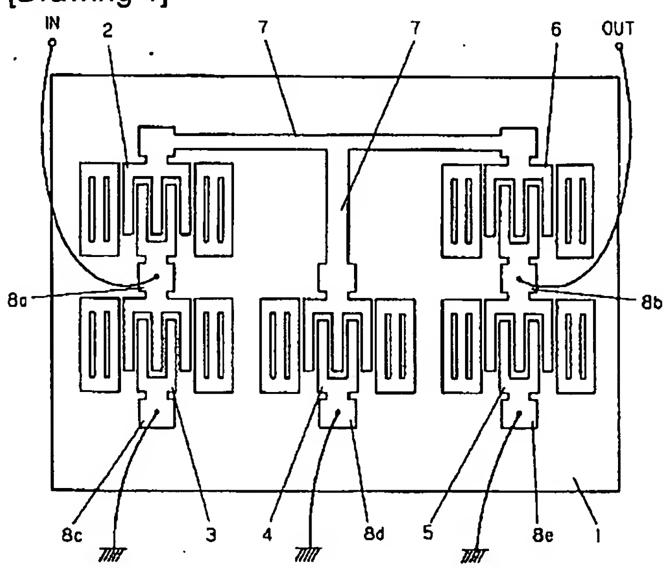
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

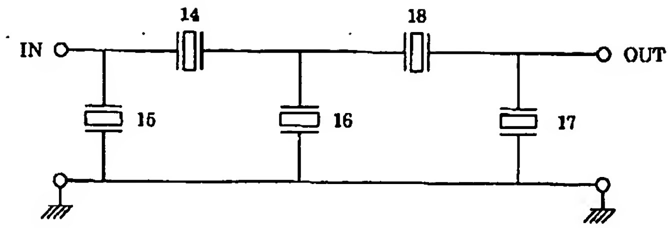
3.In the drawings, any words are not translated.

DRAWINGS

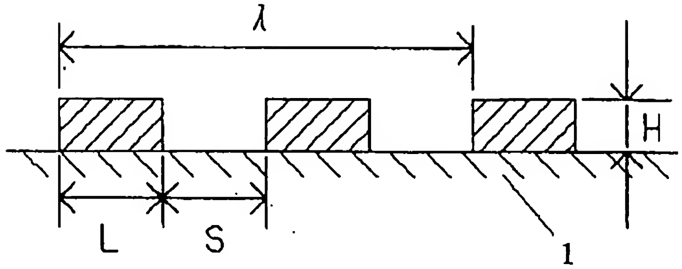
[Drawing 1]



[Drawing 6]



[Drawing 2]


λ
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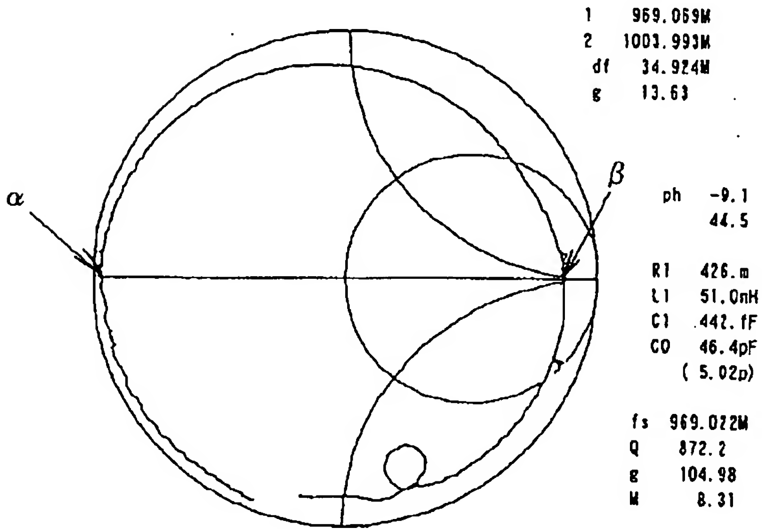
S
1

(a)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2 1003.993M
df 34.924M
g 13.63
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β
ph -9.1
44.5
R1 426.m
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C1 442.fF
C0 46.4pF
(5.02p)
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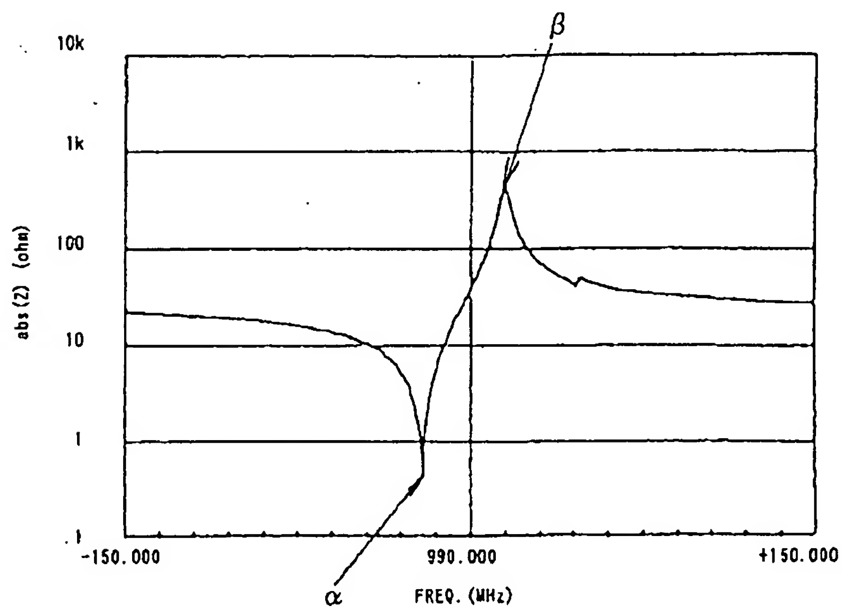
(b)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10k
1k
100
10
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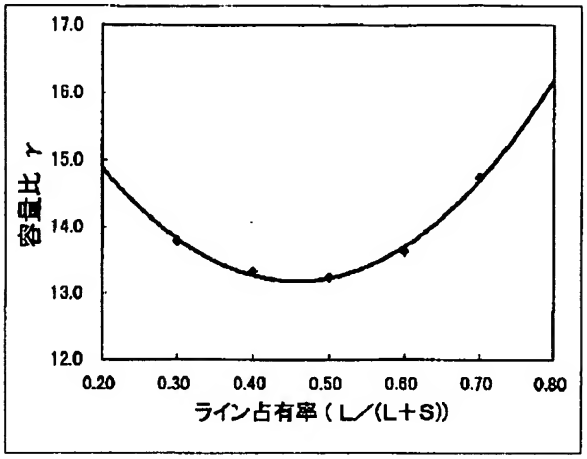
abs(Z) (ohm)
-150.000
990.000
+150.000
α
FREQ. (MHz)

(c)

[Drawing 3]



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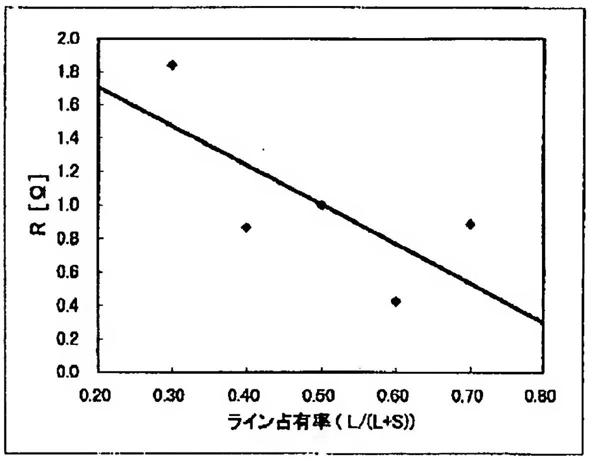
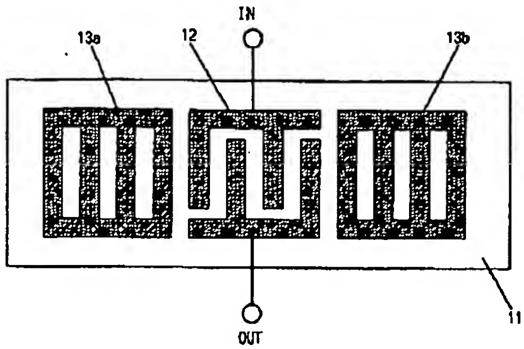


(b)

[Drawing 5]



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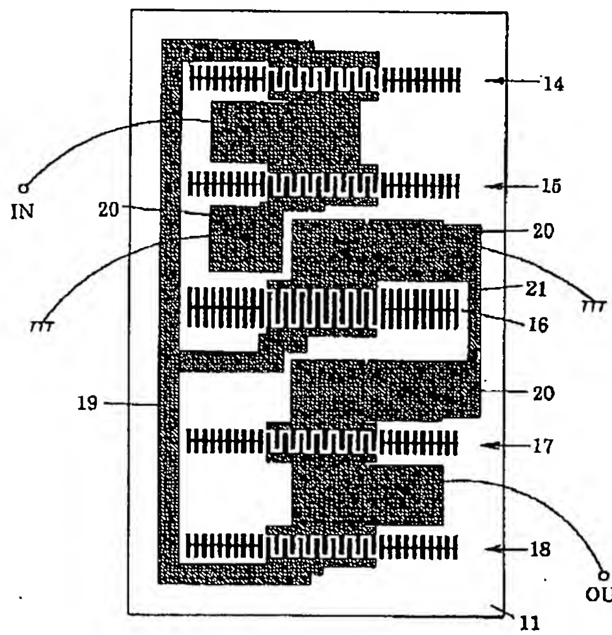
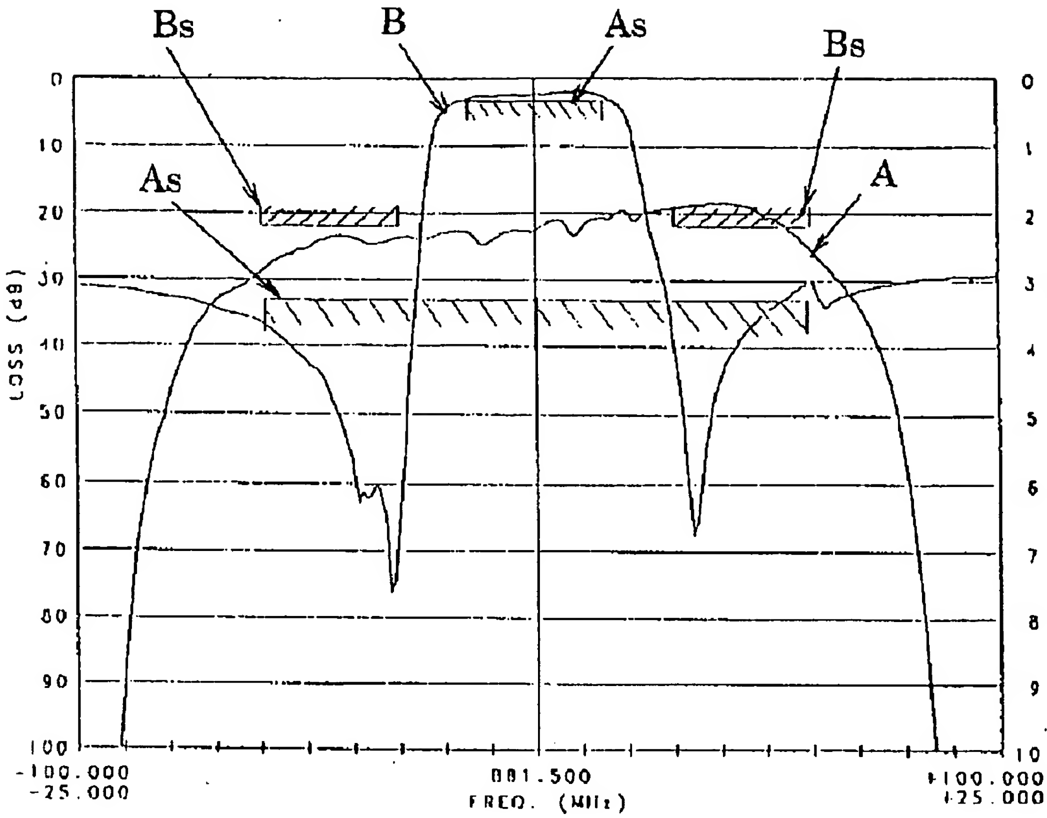


(b)

[Drawing 4]


Bs
B
As
Bs
As
A
LOSS (dB)
LOSS (dB)
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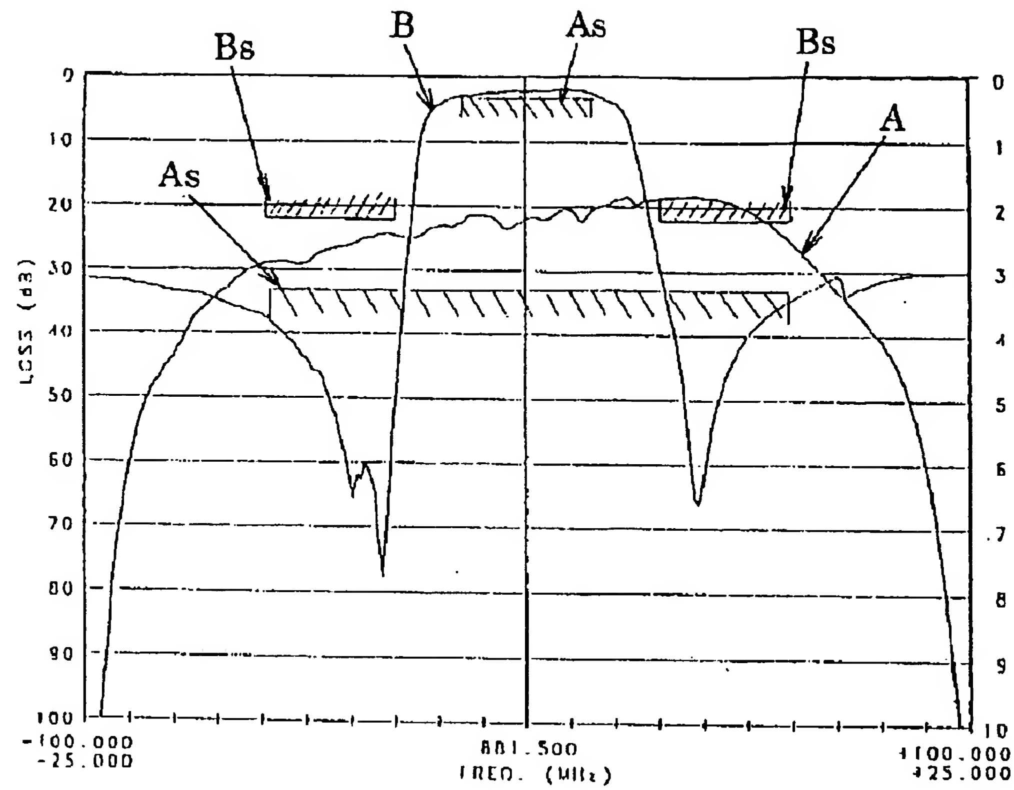
-25.000
881.500
FREQ. (MHz)
+100.000
+25.000

[Drawing 7]



[Translation done.]

(19) 日本国特許庁 (JP)　　(12) 公開特許公報（Ａ）　　(11) 特許出願公開番号

特開２０００－１５１３５５
（Ｐ２０００－１５１３５５Ａ）
(43) 公開日　平成12年5月30日 (2000. 5. 30)

(51) Int. Cl.⁷		識別記号	F I			テーマコード (参考)
Ｈ０３Ｈ	9/64		Ｈ０３Ｈ	9/64	Z	5J097
	9/145			9/145	D	
	9/25			9/25	C	
					Z	

審査請求　未請求　請求項の数２　　ＯＬ　　（全７頁）

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東洋通信機株式会社内

Ｆターム (参考)　5J097 AA18 AA28 BB01 BB15 CC01
DD05 DD13 DD15 DD16 DD25
DD28 GG03 KK01 KK02 KK04

(54)【発明の名称】ラダー型ＳＡＷフィルタ

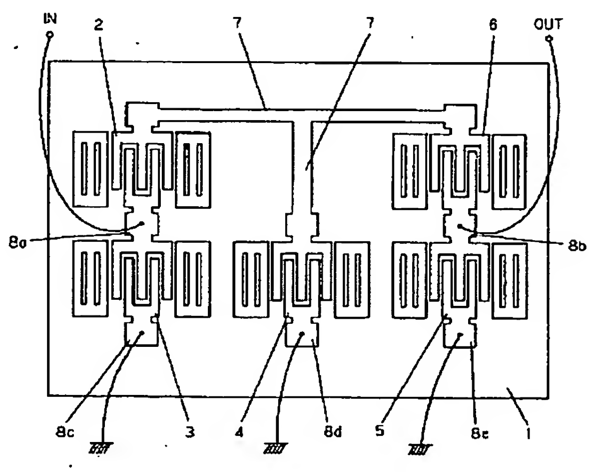
(57)【要約】

【課題】　圧電基板上に複数のＳＡＷ共振子を配置して構成するラダー型ＳＡＷフィルタの減衰傾度を急峻にする手段を得る。

【解決手段】　圧電基板上に表面波の伝搬方向に沿ってＩＤＴ電極とその両側にグレーティング反射器を配して形成するＳＡＷ共振子を、複数個配設して構成するラダー型ＳＡＷフィルタにおいて、前記ＩＤＴ電極及び前記グレーティング反射器の電極指幅Ｌとスペースとの関係を

０．５５≦Ｌ／（Ｌ＋Ｓ）≦０．７５

としたラダー型ＳＡＷフィルタである。



【特許請求の範囲】

【請求項１】　タンタル酸リチウム基板上に表面波の伝搬方向に沿ってＩＤＴ電極とその両側にグレーティング反射器を配してなるＳＡＷ共振子を複数個配設して構成するラダー型ＳＡＷフィルタにおいて、前記ＩＤＴ電極及び前記グレーティング反射器の電極指幅Ｌとスペース Ｓとの関係を

０．５５≦Ｌ／（Ｌ＋Ｓ）≦０．７５

としたことを特徴とするラダー型ＳＡＷフィルタ。

【請求項２】　切断角度θが３８°≦θ≦４４°のタンタル酸リチウム基板を用いたことを特徴とする請求項１記載のラダー型ＳＡＷフィルタ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明はラダー型ＳＡＷフィルタに関し、特に通過域近傍の減衰傾度を改善したラダー型ＳＡＷフィルタに関する。

【０００２】

【従来の技術】近年、ＳＡＷデバイスは通信分野で広く利用され、高性能、小型、量産性等の優れた特徴を有することから特に携帯電話器等に多く用いられている。携帯電話器等のＲＦ段に用いらるＳＡＷフィルタの１種に、同一圧電基板上に一端子対弾性表面波共振子（以下、ＳＡＷ共振子と称す）複数個を並、直列に配置した所謂ラダー型ＳＡＷフィルタである。ラダー型ＳＡＷフィルタの特徴は、他の電子部品に比べてＱ値の高いＳＡＷ共振子のみで構成するため、低挿入損失であると共に、急峻な減衰傾度のフィルタを実現できることから、近年、携帯電話等のＲＦフィルタとして広く用いられるようになった。

【０００３】図５は、ラダー型ＳＡＷフィルタを形成するＳＡＷ共振子１個の構成を示す電極パターンの平面図であり、圧電基板１１上に表面波の伝搬方向に沿ってＩＤＴ電極１２とその両側にグレーティング反射器１３ａ、１３ｂを配置してＳＡＷ共振子を構成したものである。ＩＤＴ電極１２はそれぞれ互いに間挿し合う複数本の電極指を有する一対のくし形電極により構成され、ＩＤＴ電極１２の一方のくし形電極は入力端子とし、他方のくし形電極は出力端子として用いる。

【０００４】図５（ｂ）に示すラダー型ＳＡＷフィルタは、圧電基板１１上に表面波の伝搬方向に沿って、図５（ａ）に示すＳＡＷ共振子と同様なＳＡＷ共振子５個（１４～１８）を互いに影響を及ぼさない距離を置いて配置し、それらを並列、直列、並列、・・と順次ラダー構造になるように信号線１９、アース電極２０及びアース線２１を用いて接続したものである。

【０００５】図５（ｂ）に示すラダー型ＳＡＷフィルタの電気的等価回路を、圧電共振子（ＳＡＷ共振子も圧電共振子の１種）を表す符号を用いて模式的に表すと、図６に示すラダー型回路となる。即ち、図５（ｂ）に示した各素子のうち、ＳＡＷ共振子１４、１８は入出力端子に対し直列アームに、ＳＡＷ共振子１５、１６、１７は並列アームに接続されている。図６に示す各ＳＡＷ共振子の周波数と電気的諸定数とをフィルタ理論に従って設定し、適当に終端すれば、有極構成の帯域濾波器として機能することは良く知られている。

【０００６】ＳＡＷデバイスの改良は年々急速に進展しており、例えば特開平９－１６７９３６に開示されているように、タンタル酸リチウム（$LiTaO_3$）基板上にラダー型ＳＡＷフィルタを形成する際の挿入損失、減衰傾度等は、基板の切断方位と電極膜厚とに大きく依存することが開示されている。即ち、電極膜厚Ｈ／λ（λは励起される表面波の波長）が０．０７≦Ｈ／λ≦０．１、基板の切断方位Ｙが３８°≦Ｙ≦４４°の条件を満たすようにラダー型ＳＡＷフィルタを形成すると、挿入損失が低損失になると共に、通過域近傍の減衰傾度が急峻なラダー型ＳＡＷフィルタが得られることが記述されている。

【０００７】図７は、圧電基板に42° Y-X $LiTaO_3$を用い、電極にアルミニウム合金の膜厚Ｈ／λを0.08、ＩＤＴ電極対数を100対、反射器の本数をそれぞれ100本、電極指の交差幅Ｗを30λ、共振周波数を880ＭＨｚ帯としたＳＡＷ共振子５個を図６に示すように並直列に接続したフィルタの濾波特性をシミュレーションによりもとめた図で、フィルタ特性について阻止域を含めて図示したものＢと、通過域のみを拡大して図示したものＡが重ね書きされている。拡大したフィルタ特性のロス（Loss）は右側の縦軸に、周波数（Freq.）は下段の数値に対応している。尚、ハッチングで示すＡｓは通過域の規格を示し、Ｂｓは減衰域の規格を示している。尚、電極指幅（ライン幅）Ｌと電極指間スペースＳの寸法（以下、スペース幅と称す）とを等しく設定している。

【０００８】

【発明が解決しようとする課題】しかしながら、米国のAMPS方式では９００ＭＨｚ帯の周波数を用い、送受の周波数間隔が２０ＭＨｚであり、比帯域が4.5％のＲＦフィルタが必要であるに対し、新たなPCS方式では周波数帯が１．９ＧＨｚ帯に移行したにも拘わらず送受の周波数間隔が２０ＭＨｚのままであり、ＲＦフィルタとして比帯域4.0％と狭帯域かつ通過域近傍の減衰傾度は従来のものに比べてより急峻にする必要が生じている。上記のラダー型ＳＡＷフィルタでは、新しい規格を満たすことが極めて難しいという問題があった。本発明は上記問題を解決するためになされたものであって、減衰傾度を改善したラダー型ＳＡＷフィルタを提供することを目的とする。

【０００９】

【課題を解決するための手段】上記目的を達成するために本発明においては、ＩＤＴの電極指幅Ｌとスペース幅Ｓとの関係を吟味した結果、以下のようにすれば目的を

達成し得ることを見出した。即ち、請求項１記載の発明は、圧電基板上に表面波の伝搬方向に沿ってＩＤＴ電極とその両側にグレーティング反射器を配してなるＳＡＷ共振子を複数個配設して構成するラダー型ＳＡＷフィルタにおいて、ＩＤＴ電極及びグレーティング反射器の電極指幅ＬとスペースＳとの関係を

０．５５≦Ｌ／（Ｌ＋Ｓ）≦０．７５

としたことを特徴とするラダー型ＳＡＷフィルタである。請求項２記載の発明は、切断角度θが３８°≦θ≦４４°のタンタル酸リチウム基板を用いたことを特徴とする請求項１記載のラダー型ＳＡＷフィルタである。

【００１０】

【発明の実施の形態】以下本発明を図面に示した実施の形態に基づいて詳細に説明する。図１は本発明に係るラダー型ＳＡＷフィルタの構成を示す平面図であって、圧電基板１上に図５で説明したようなＳＡＷ共振子５個（ＳＡＷ共振子２～６）を配し、リード電極７及び複数の電極パッド８ａ～ｅを用いて、並、直列に接続してラダー型ＳＡＷフィルタを構成したものである。それぞれのＳＡＷ共振子２～６は互いに影響を及ぼさない距離を隔して配置されている。また、電極パッド８ａと入力端子IN、電極パッド８ｂと出力端子OUTとをワイヤボンディングを用いて電気的に接続し、電極パッド８ｃ～８ｅはそれぞれ接地してラダー型ＳＡＷフィルタを構成する。

【００１１】ラダー型ＳＡＷフィルタの挿入損失、通過域近傍の減衰傾度を改善するには、フィルタを構成しているＳＡＷ共振子の特性、例えば電気的等価抵抗Ｒ、容量比γ等を改善する必要がある。そこで発明者は、ＳＡＷ共振子の断面図の一部を示す図２のように、電極指幅（ライン幅）Lとスペース幅Sとを定義したとき、両者の和に対する電極指幅Lの比、即ちライン占有率L／(L+S)とＳＡＷ共振子の電気的等価抵抗Ｒ及び容量比γの関係を求めるべく、種々実験を重ねた。尚、同図においてλは一波長に相当し、Hは電極膜の厚みであり、一般にＳＡＷ共振子の膜厚をH／λで表現する。圧電基板に42° Y-X $LiTaO_3$を用い、電極にアルミニウム合金の膜厚H／λを0.08、ＩＤＴ電極対数を100対、反射器の本数をそれぞれ100本、電極指の交差幅Wを30λとし、周波数は900ＭＨｚ帯とした。ライン占有率L／(L+S)を0.3から0.7まで0.1きざみで変化させ、その時の円線図と共振特性とを測定して、共振周波数f_s、反共振周波数f_a、容量比γ、等価抵抗Ｒ及びスプリアスを測定した。

【００１２】図２（ｂ）、（ｃ）に示した円線図及び共振特性は測定した一例であり、点αは共振周波数、点βは反共振周波数を示している。図３（ａ）、（ｂ）は、以上の測定から得られたデータを、それぞれ容量比γと電気的等価抵抗Ｒとに分け、ライン占有率L／(L+S)に対してプロットした図である。図３（ａ）から容量比γはライン占有率L／(L+S)が約0.47のとき最小値となることが分かる。また、図３（ｂ）からライン占有率の増加につれて電気的等価抵抗Ｒは概ね減少する傾向にある。

【００１３】発明者は容量比γが小さく、等価抵抗Ｒも小さいＳＡＷ共振子を用いてラダー型ＳＡＷフィルタを構成した場合に、挿入損失が小さく、通過域近傍の減衰傾度が急峻になると考え実験してきたが、容量比γが最小値よりも少し大きな値のＳＡＷ共振子を用いてラダー型ＳＡＷフィルタを構成したところ、通過域帯域幅は容量比γが最小なものと同等で、通過域近傍の減衰傾度はむしろ急峻になることを見出した。

【００１４】そこで、上記のことを確認すべく圧電基板に42° Y-X $LiTaO_3$を用い、電極にアルミニウム合金の膜厚H／λを0.08、ＩＤＴ電極対数を100対、反射器の本数をそれぞれ100本、電極指の交差幅Wを30λ、共振周波数を880ＭＨｚ帯としたＳＡＷ共振子５個を図６のにように並直列に接続したフィルタの濾波特性を、前記のＳＡＷ共振子の容量比γ、電気的等価抵抗Ｒ等の実験値を用いて、シミュレーションによって求めた。図４は、ＳＡＷ共振子の容量比γが最小値より少し大きな値を呈するライン占有率0.7に設定した場合の濾波特性を示した図で、フィルタ特性について阻止域を含めて図示したものＢと、通過域のみを拡大して図示したものＡが重ね書きされている。拡大したフィルタ特性のロス（Loss）は右側の縦軸に、周波数（Freq.）は下段に数値に対応している。尚、ハッチングを施したＡｓは通過域の規格、Ｂｓは減衰域の規格を示したものである。図４と図７とから明らかなように、ライン占有率が0.7を用いたラダー型ＳＡＷフィルタの方が通過域近傍の減衰傾度が急峻であることが分かる。

【００１５】さらに、図４、７を詳細に検討すると最小損失から1.5dB減衰した所の通過帯域幅は両者ともほぼ同じ値を示すが、30dB減衰した所の帯域幅はライン占有率0.7を用いたラダー型ＳＡＷフィルタの方が、ライン占有率0.5のフィルタより約7%ほど狭くなっていることが分かった。即ち、ライン占有率を0.7に設定したラダー型ＳＡＷフィルタの方がライン占有率を0.5に設定したフィルタより通過域近傍の減衰傾度が急峻になるということである。さらに、容量比γ、電気的等価抵抗Ｒ等に実験値を用い、ライン占有率をパラメータにしてラダー型ＳＡＷフィルタの濾波特性をシミュレーションにより求めたところ、ライン占有率L／(L+S)が0.55≦ L／(L+S) ≦0.75の関係を満たすときにライン占有率0.5とした従来のフィルタより減衰傾度が改善されることが分かった。

【００１６】以上の説明では圧電基板上に配列したＳＡＷ共振子のＩＤＴ電極及びグレーティング反射器のライン占有率を同じ比で変化させた場合について、通過域近傍の減衰傾度が改善される関係を求めたが、ライン占有率を変化させると共振周波数も変化するため、グレーティング反射器が形成するストップバンドの中心地をフィ

ルタの帯域幅に対して最適になるようにグレーティング反射器の波長を調整することはいうまでもない。

【００１７】また、以上の説明では、タンタル酸リチウム基板の切断角度θを42度を用いた場合について説明したが、切断角度が38°≦θ≦44°の範囲の切断角度を用いても上記と同様な結果が得られた。また、電極膜厚Ｈ／λについて0.08の場合について説明したが、この値に限ることなく0.07≦ Ｈ／λ≦0.1の範囲に設定したものについても同様な結果が得られた。

【００１８】

【発明の効果】本発明は、以上説明したように構成したので、通過域近傍の減衰傾度を急峻にすることが可能となった。従って、本発明になるフィルタを1.9GHz帯の携帯電話等のＲＦフィルタに用いれば通信品質の優れた携帯電話が実現できるという優れた効果を奏す。

【図面の簡単な説明】

【図１】本発明に係るラダー型ＳＡＷフィルタの構成を示す平面図である。

【図２】（ａ）ライン占有率を説明する図、（ｂ）円線図、（ｃ）共振特性を示す図である。

【図３】（ａ）ライン占有率L／(L+S)と容量比γとの関係を示す図、（ｂ）ライン占有率L／(L+S)と電気的等価抵抗Ｒとの関係を示す図である。

【図４】本発明に係るラダー型ＳＡＷフィルタの濾波特性を示す図である。

【図５】（ａ）ＳＡＷ共振子の構成を示す図、（ｂ）ラダー型ＳＡＷフィルタの構成を示す図である。

【図６】ラダー型ＳＡＷフィルタの電気的等価回路である。

【図７】従来のラダー型ＳＡＷフィルタの濾波特性を示す図である。

【符号の説明】

１・・圧電基板

２、３、４、５、６・・ＳＡＷ共振子

７・・リード電極

８ａ、８ｂ、８ｃ、８ｄ、８ｅ・・電極パッド

L・・電極指幅（ライン幅）

S・・スペース

λ・・波長

H・・電極膜厚

α・・共振点

β・・反共振点

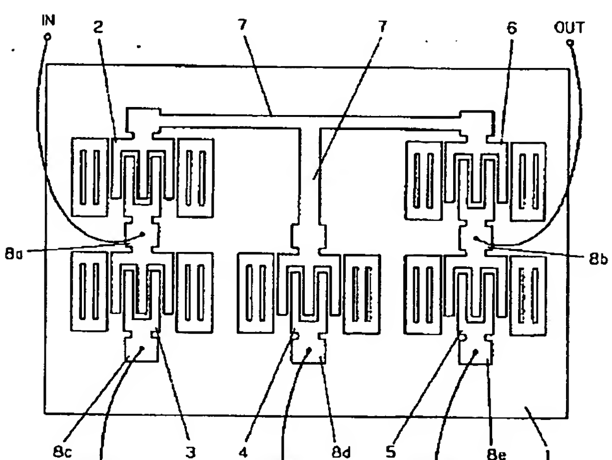
Ａ・・通過域特性

Ｂ・・減衰域特性

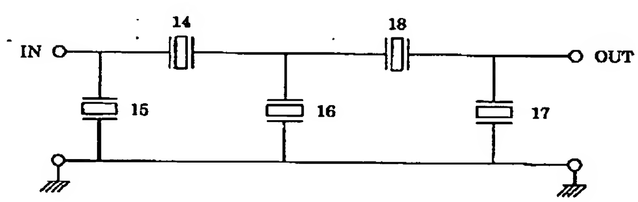
Ａｓ・・通過帯域の規格

Ｂｓ・・減衰域の規格

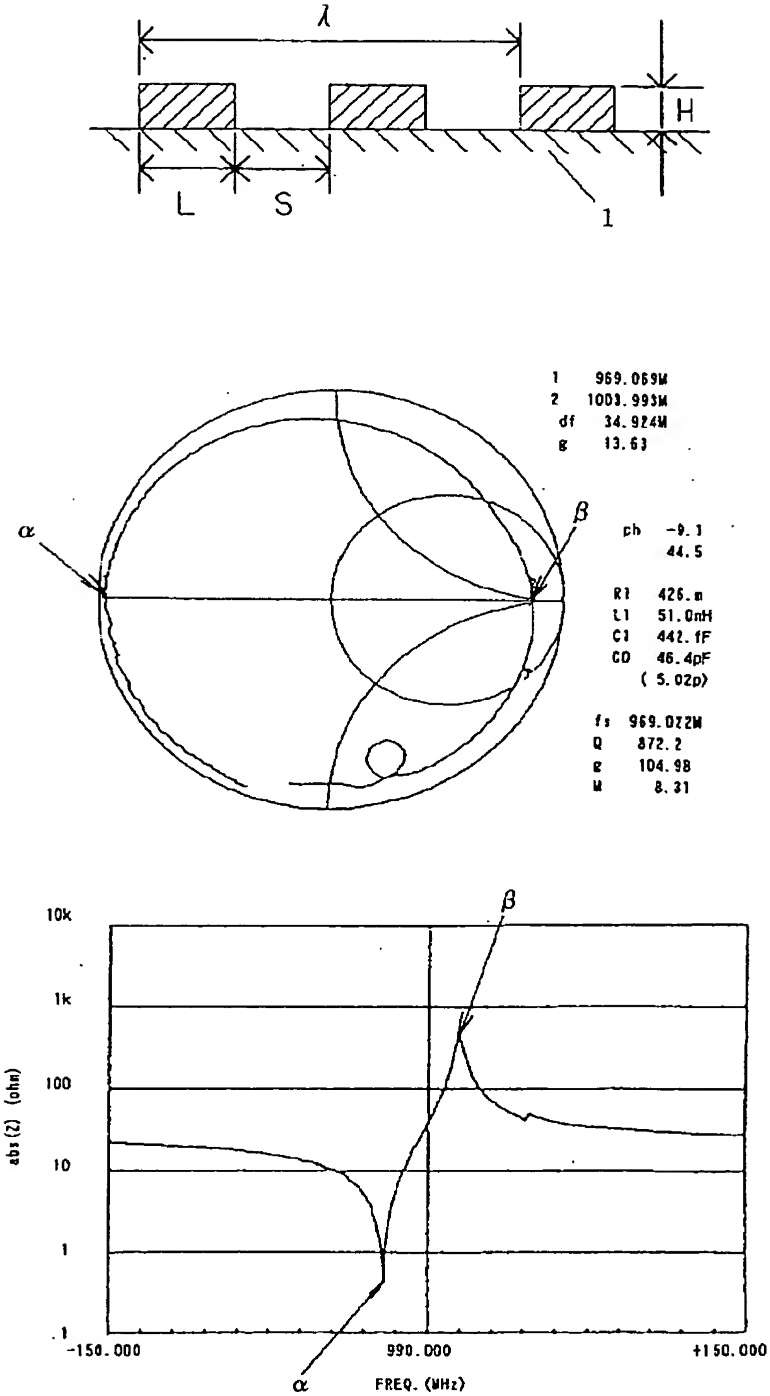
【図１】



【図６】



【図２】

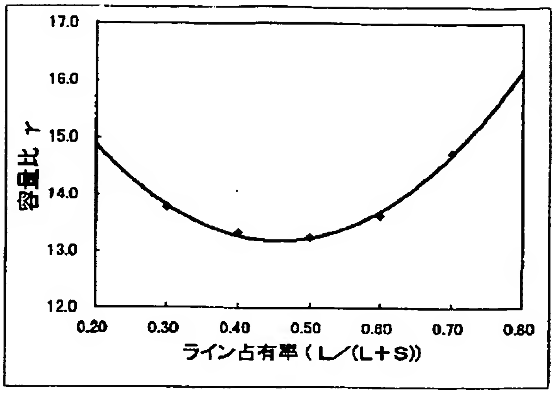

λ
H
L
S
1
1 969.069M
2 1003.993M
df 34.924M
g 13.63
α
β
ph -9.1
44.5
R1 426.m
L1 51.0nH
C1 442.fF
C0 46.4pF
(5.02p)
fs 969.022M
Q 872.2
g 104.98
M 8.31
10k
1k
100
10
1
.1
abs(Z) (ohm)
-150.000
990.000
+150.000
FREQ. (MHz)

（ａ）

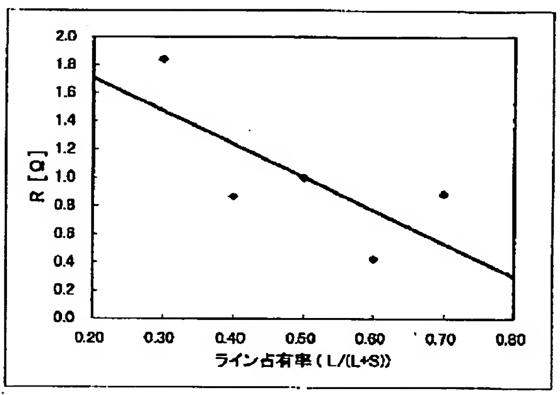
（ｂ）

（ｃ）

【図３】

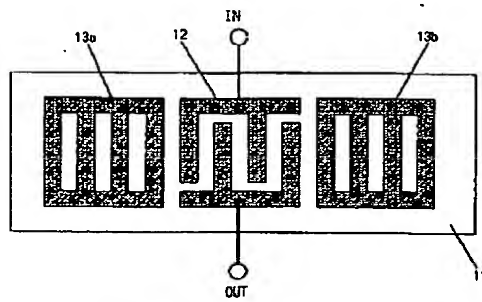

17.0
16.0
15.0
14.0
13.0
12.0
容量比 γ
0.20 0.30 0.40 0.50 0.60 0.70 0.80
ライン占有率（L／(L＋S))

(a)

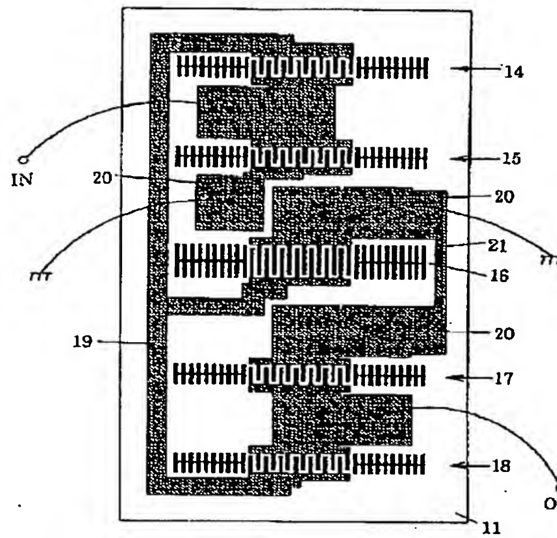

2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
R [Ω]
0.20 0.30 0.40 0.50 0.60 0.70 0.80
ライン占有率（L/(L+S))

(b)

【図５】

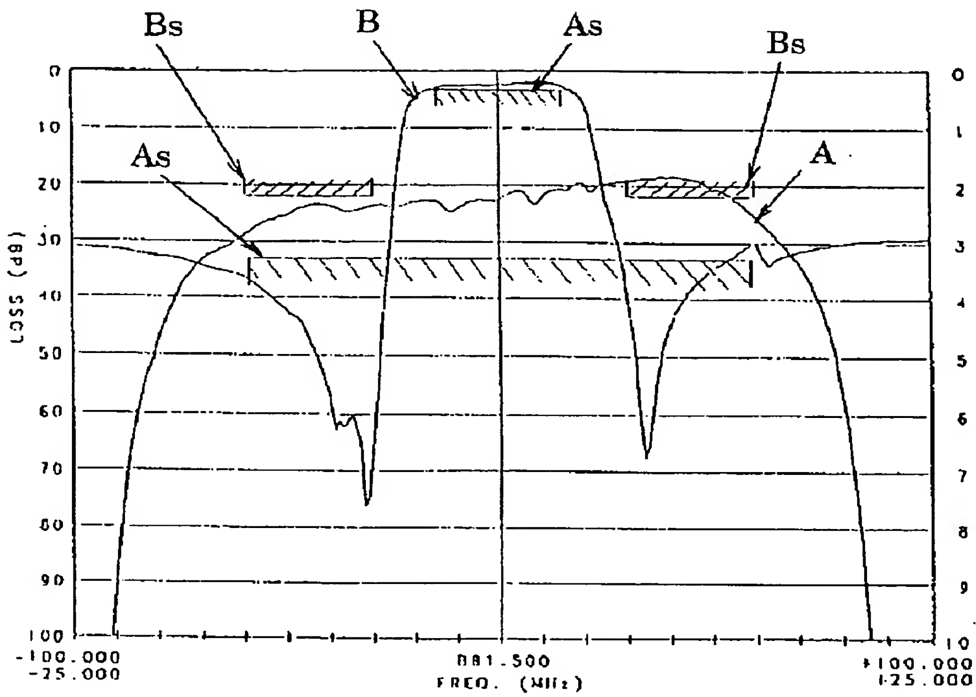

IN
13a
12
13b
OUT
11

(a)

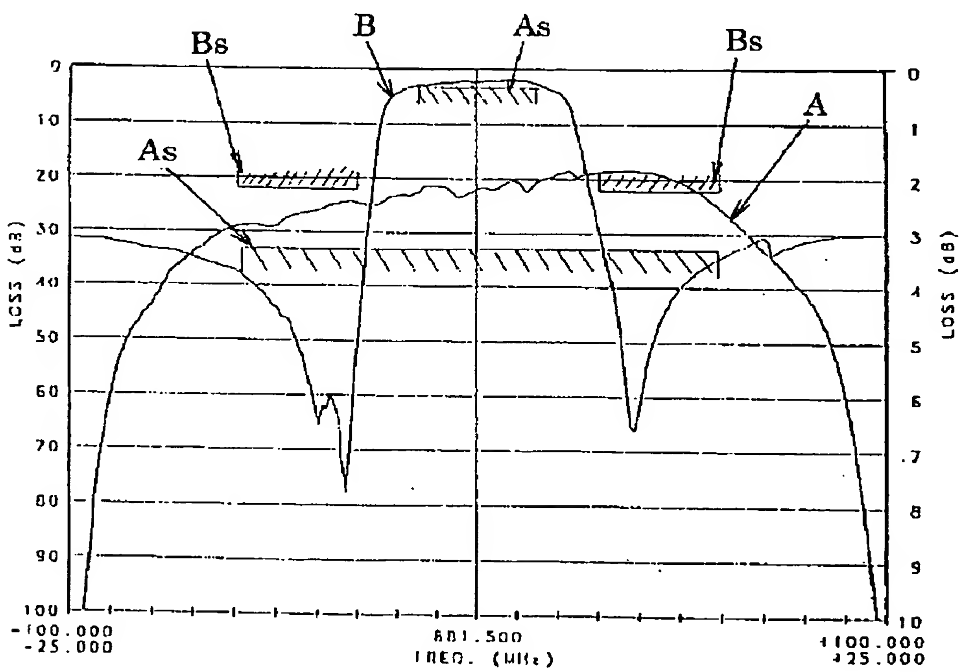

14
IN
15
20
20
21
16
20
19
17
18
OUT
11

(b)

【図４】


Bs
B
As
Bs
As
A
LOSS (dB)
LOSS (dB)
-100.000
-25.000
881.500
FREQ. (MHz)
+100.000
+25.000

【図７】


Bs
B
As
Bs
As
A
LOSS (dB)
LOSS (dB)
-100.000
-25.000
881.500
FREQ. (MHz)
+100.000
+25.000